

MARTIAN VOLCANIC COMPOSITIONS AND DISTRIBUTIONS: RESULTS FROM THE THERMAL EMISSION SPECTROMETER. J.L. Bandfield, P.R. Christensen, and V.E. Hamilton, Department of Geology, Arizona State University, Tempe, AZ 85287-1404 (joshband@imap3.asu.edu)

Introduction: Martian low albedo regions exhibit distinctive absorptions in the 8-12 and 20-50 μm regions of the electromagnetic spectrum [1,2]. These absorptions contain abundant information regarding the mineralogical composition of these regions. Because atmospheric dust, water ice, carbon dioxide, and water vapor contain numerous absorptions throughout the Martian spectrum, two surface-atmosphere separation algorithms have been developed to obtain these atmospherically corrected surface spectra. These models derive consistent spectral signatures under a variety of atmospheric conditions [3,4]. With accurate surface spectra, mineralogical information about low albedo regions may be determined and any spatial variations in composition may be mapped globally.

Method: Several dozen locally homogeneous, low albedo locations were selected from mapping and science phasing orbit data with low dust and water ice opacities. Up to several hundred spectra from each location, covering north-south strips ~50 to several hundred km in size were averaged for spectral component determination. The surface-atmosphere separation as summarized in [3] was applied to these data using locally derived atmospheric shapes [5,6]. The result is a set of spectra representing the surface components of the regions. Spectral endmembers selected from the set of low albedo surface spectra as well as hematite from Sinus Meridiani [7,8] and low spectral contrast (virtually blackbody in the 8-12 and 20-50 μm regions) high-albedo region surface spectra were then used along with a set of atmospheric spectral shapes to perform a least squares fit of the global set of TES emissivity spectra. The concentration images of each of the spectral shapes as well as the RMS error image between measured and modeled spectra were then examined to determine spatial distributions. The RMS error image was also examined to determine if additional surface components are needed to model areas of high error.

Results: Spectral shapes. The surface spectral signatures from the selected low albedo regions are broadly similar in that all surface spectral shapes contain broad absorptions at both the 8-12 and 20-50 μm wavelength regions. The depth of the absorptions varies between ~0.04 and 0.09 in emissivity. However, some differences exist and the spectra may be grouped into three categories: 1) A surface signature with a broad, slightly square shaped absorption

between 8 and 12 μm with an absorption throughout the 20-50 μm region. The longer wavelength absorption has a negative slope with increasing wavelengths and contains superimposed minor, narrow absorptions. 2) A second surface spectral shape contains a more rounded, slightly V-shaped 8 to 12 μm region absorption. The long wavelength absorption is quite flat with no readily discernible minor absorptions. A significant rise in emissivity is present at wavelengths just short of 20 μm . 3) The third surface spectral shape is intermediate between the first two types. Whether this represents a mixture of the two surface compositions or an intermediate composition is not clear.

Compositions. The locations of reststrahlen features in the 8-12 μm region of silicate rock spectra shift from shorter to longer wavelengths with increasing mafic composition and may be used as a first order indication of the surface mineralogy [9]. The location of the features in the first type of derived surface spectrum is indicative of a dominantly mafic mineralogy (resembling basaltic spectra) and is not similar to spectra of more felsic rocks such as rhyolite and andesite. The second surface type contains a 8-12 μm absorption that is more consistent with a more felsic mineralogy however, as will be discussed, this may also be due to glasses or clays which do not follow the trend of increasing wavelength of absorption with increasing mafic composition well.

The surface spectra match well with sample spectra of two terrestrial volcanic rock types. The first surface type closely matches the spectral signature of a terrestrial flood basalt. This sample has a composition that is approximately 65% feldspar and 30% hi-Ca pyroxene by volume and contains minor amounts of weathering products such as serpentine. Spectra of other crystalline basalts and basaltic andesites composed primarily of plagioclase and hi-Ca pyroxene also compare favorably to the first Martian surface signature type. The second surface signature type compares favorably to basalts and andesites which contain significant amounts of volcanic glass. A sample of basaltic andesite composed of 45% glass, 10% pyroxene, and 40% plagioclase provides the closest spectral match to the Martian spectrum. These spectra are consistent with extrusive rock types and do not match well with plutonic rock sample spectra [10].

Mineral abundance determination from deconvolution [11-13] provided results consistent with the empirical comparison of Martian spectra with terrestrial rock spectra discussed above. The derived mineralogy of the first surface type is dominated by plagioclase feldspar and hi-Ca pyroxene with minor amounts of sheet silicates and olivine at or below the detection limit of ~10-15%. The derived composition of the second surface type is dominantly plagioclase feldspar and volcanic glass with pyroxene and sheet silicates at or near the detection limits.

Distributions. The distribution of these two volcanic compositions was obtained from the several million spectra in the global dataset. Most spectra were modeled with low RMS errors of <0.01 emissivity with the exception of areas with extreme water ice opacities or low signal to noise due to low surface temperatures. As expected, the total abundance of the two volcanic surface spectra displays a high correlation with low albedo regions.

The two surface spectral types show individual distributions split along the hemispheric dichotomy boundary. Concentrations of the first surface spectral type are located primarily in the cratered southern highlands regions such as Terra Cimmeria and Syrtis Major. The second surface spectral signature type is concentrated in the Acidalia Planitia and the circum-polar sand seas in Vastitas Borealis. Mixtures or intermediate compositions of these two spectral types (consistent with the third surface type) occurs in several regions including Margaritifer Terra, Utopia Planitia, and localized areas within Syrtis Major. The global locations of derived surface types agree well with the individually retrieved spectral signatures.

Conclusions: Results from the analysis of Thermal Emission Spectrometer data indicate that much of the low albedo Martian surface is composed of two volcanic compositions: 1) A crystalline basalt or basaltic andesite composed primarily of plagioclase feld-

spar and hi-Ca pyroxene, and 2) a composition composed of primarily plagioclase feldspar and volcanic glass which is consistent with basaltic to andesitic rock types. A third spectral shape is a mixture or intermediate composition of these two endmembers. The two primary compositions are split roughly along the hemispheric dichotomy with the glassy composition concentrated in the northern lowlands and the more crystalline composition concentrated primarily in southern highlands regions and Syrtis Major.

More detailed mapping with a more complete dataset will be able to provide a more precise distribution of these two volcanic compositions and provide a better relation to source regions. In addition, while this study provides a regional view, more detailed studies are needed to determine if other volcanic and igneous compositions, such as those consistent with the Martian meteorites [14], are exposed locally on the Martian surface. The Martian surface spectra examined thus far are not consistent with the laboratory spectra of these meteorites.

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